AN INVESTIGATION OF VARIABLE OPERATING AND SAFETY LEVEL (VOSL) STOCKING AND FUNDING POLICY

Richard Earl Lewis

NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

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by

Richard Earl Lewis

and

Robert Darol Perkins

Thesis Advisor: D.A. Schrady

March 1974

Approved for public release; distribution unlimited.

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by

Richard Earl Lewis
Lieutenant Commander, Supply Corps, United States Navy
B.S., University of Idaho, 1965

and

Robert Darol Perkins
Lieutenant Commander, Supply Corps, United States Navy
B.S., Texas College of Arts and Industries, 1960

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN OPERATIONS RESEARCH

from the

NAVAL POSTGRADUATE SCHOOL
March 1974

ABSTRACT

Control in the management of stocks of retail material (DSA) at Navy stock points is exercised through a centrally administered stocking policy model (VOSL) and funding policy. The dynamic behavior of these controls operating on a stock point was investigated by computer simulation. The simulation results indicate that under the most favorable circumstances, the value of resupply orders directed by the VOSL stocking model exceeded the grants made by the funding policy. Under less favorable, more realistic conditions, the difference between funding requirements and funding grants is more marked and supply performance degrades very significantly over time. The funding dilemma investigated in this study is well known to Navy stock points and they have devised various ways of attempting to deal with it. Significantly, even in a climate of insufficient funding, system stocking policies (VOSL) provide better performance than locally devised policies.

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I. INTRODUCTION

A. BACKGROUND

With the establishment of the Defense Supply Agency (DSA) wholesale operation, it was no longer possible for the Navy to maintain large quantities of backup stocks. However to maintain the desired levels of fleet support, a new scientific inventory management program for the various stock points was essential. This ultimately resulted in the Variable Operating and Safety Level - Requisitions Short Model (VOSL-RSM) for inventory control and the Financial Management (funding) policy in use today for 9-COG items.

The basic VOSL model was designed to find a trade off between concentrating investment in the high dollar demand categories or in the low dollar demand categories. Stated another way, the model finds a trade off between sales and line item effectiveness. The model was also constrained to allow a maximum of 2.5 months of stock on hand. This 2.5 months of stock on hand was composed of two parts. The first part, α, represents the portion of the inventory supporting demands while the second part, $(2.5 - \alpha)$, represents the portion of the inventory allocated as safety stock. The requisitions short modification to the original VOSL model seeks to improve requisition effectiveness by allocating the funds available for investment in safety stock.

This thesis investigates the adequacy of the stocking and funding policies from the users' point of view; the users

being stock points. Personal contact and discussion with a West Coast stock point (hereafter referred to as Stock Point A) concerning problems they were experiencing with VOSL-RSM provided the initial motivation for this study. Additional informal contact with several other stock points enhanced this motivation and provided strong indications that VOSL-RSM is not always operating as the stock points would desire.

One of the initial steps of this study was to obtain from the Fleet Material Support Office (FMSO) a Master Stock Point Record (MSPR) tape for Stock Point A dated January 1973. A random sample of 864 line items on this tape indicated a zero on hand balance for 50.7 percent of the sample. The on order position for these items could not be determined with any degree of accuracy since in many cases this data position on the tape was either zero filled or there was really nothing on order. In either event, some problem was clearly evident. Stock Point A indicated that their stock position had not significantly improved since the date of the MSPR tape, because sufficient funds were not available to utilize the optimal order quantities generated by VOSL-RSM. Thus, they were forced to constrain the value of inventory resupply requisitions in order to operate within funding limits; i.e., they had to ignore both the VOSL rules and the VOSL ANALYZER and invent their own rules. For example, some stock points have:

(1) placed a monetary limit of ten dollars on resupply requisitions

(2) set order quantities to be equal to 30 days of forecasted demand

(3) set reorder points to zero

(4) modified stocking and replenishment criteria to stock and order only those items having at least six demands in six months.

Contact with people at the working level at Stock Point A revealed two widely separated views concerning the source/cause of the problem. On one side, the financial management people argue that since funds are granted on a sales replacement basis an efficiently functioning stock control branch should be able to operate normally within the funding limitations. This argument ignores such factors as large increases in quantity of demand, increases in lead time, inflation, and bad buys. The last factor, bad buys, are unavoidable in most cases and can be a real crippler even when countered with a super aggressive excessing policy. Unless a stock point is fortunate enough to have a clairvoyant stock control officer who can predict demand on individual line items with complete certainty, the bad buy problem can only get worse.

To return to the other side of the house, the stock control people contend that funds are never adequate and when funds are reduced for any reason, the on hand stock position is degraded. This ultimately will reduce sales and correspondingly reduce the funds available for stock replacement. The arguments offered by both sides reflect the opinions most often heard in support or defense of any inventory/funding policy. Although the arguments of both sides have

some merit they are by no means a mutually exclusive, collectively exhaustive set.

B. EXISTING SYSTEM

The existing system for the management of 9-COG items is comprised of two basic policies; a stocking policy and a funding policy.

1. Stocking Policy

The stocking policy considered in this study is the existing VOSL model discussed in Ref. 1 which operates on a 2.5 month average investment level constraint. This model divides the inventory of a stock point into ten classes according to value of annual demand. The value of annual demand configuration determines the average operating level investment, α, and enables the model to compute optimal order quantities, q's. The "Requisitions Short" capability is provided by the modification to the basic VOSL model discussed in Ref. 2. This modification utilizes the previously determined α and allocates the remaining investment $(2.5 - \alpha)$ in safety stocks. This allocation is accomplished on an item by item basis and considers unit cost, frequency, order quantity, demand forecast and risk of stockout. After the safety level investment allocations are made, safety levels and reorder points are computed.

In actual operation of the VOSL-RSM there are two basic portions of the program with the first portion managed and operated by FMSO, and the second portion operated by the individual stock points. Initially the FMSO portion of the

VOSL program begins with a value of annual demand (VAD) listing which is a list of stock points' entire active inventory ordered in terms of VAD from highest to lowest. The program divides the stock points' inventory into ten classes according to VAD and determines an appropriate multiplier, λ', as discussed in Appendix B. The individual stock points then take this information provided by FMSO as inputs to their portion of the VOSL program. Their program places each individual item in its appropriate VAD class and computes optimal order quantities, safety levels and reorder points which the stock point requires for operation.

2. Funding Policy

The VOSL funding policy, as described in Ref. 3, is based on a moving average of the previous four quarters of issues, months of active stock on hand, fiscal year to date (FYTD) issues, FYTD funding and a draw-down policy for material in a long supply status. These items provide the necessary information to compute a recommended quarterly fund grant.

C. PROBLEM AREAS

There are numerous potential and/or existing problem areas in the current system. For example, the stocking policy is based on an average two and one-half month stock investment while the funding policy is based on the sales of the prior years. This seems to ve a very loose connection. It should also be noted that both the VOSL-RSM stocking

policy and the existing funding policy are rather rigid and little if any allowance is made for (1) changing demand patterns, (2) inflation, (3) bad buys, (4) increased lead times; etc. Specifically for (1) and (4), both funding and stocking the models react or adapt, but only in a painfully slow, after-the-fact manner. That is, in a tight money situation, if demand begins to increase there will not be sufficient funds to stock quantities to support the new requirement. Thus, sales will not be made, and, consequently, no increase in funding will be recieved, the following quarter. The standard rebuttal to this type argument is that the increased demand for some items will be offset by reduced demands for other items and things tend to even out in the long run. A sequence of factors as described above could (and, in fact, does) place the stock points in an increasingly untenable situation with respect to their inventory positions. In addition funding inflexibility has driven stock points to invent and implement their own stocking replenishment rules - ignoring both VOSL and the VOSL ANALYZER.

D. STUDY OBJECTIVES

The primary hypothesis of this study is that the existing VOSL-RSM stocking policy used in conjunction with the existing funding policy will not operate as designed in a dynamic "real world" environment. The secondary hypothesis is that the inventory position and effectiveness measures of

a stock point using a local, less than optimal, stocking policy will be much worse than following VOSL-RSM rules even in a climate of insufficient funds.

Specifically, the objectives of this study are to:

(1) determine if the current funding policy for 9-COG items provides sufficient funds to allow the VOSL-RSM stocking policy to operate as planned;

(2) determine the effects on funding, effectiveness, etc. when the stock point is limited to the use of actual funds granted when using optimal VOSL-RSM stocking policy; and

(3) repeat (2) using a locally constrained stocking policy instead of the VOSL-RSM stocking policy

The general method of achieving the study objectives will be by means of computer simulations designed to reflect the daily operation of a stock point over a period of ten years. The stock point operations to be simulated include not only the daily receipt and issue of materials, but also an excessing program, migration of items from an inactive to active status and vice versa, increases in unit prices due to inflation, and the stock points' portion of the VOSL-RSM stocking policy calculations. In addition the FMSO portion of VOSL-RSM stocking policy and funding calculations are included in the simulation. Underlying this was the desire to demonstrate such phenomena as the direction and orders of magnitude of performance indicators over time.

II. MODEL

A. DATA

As previously indicated, the initializing data for all simulation runs was "real world" data obtained from the MSPR tape dated January 1973 of stock point A's. A computer program was written to dump the entire contents of the tape, relative to the first 3,400 9-COG items, in order to determine which data elements would be useful. This was necessary since some data elements were known to be filled with either blanks or zeros. As a result of this determination, the data fields selected for use in the simulation were (1) on hand quantity, (2) quantity of demand during the previous four quarters, (3) frequency of demand during the previous four quarters, (4) unit price, (5) Mean Absolute Deviation (MAD) of demand, and (6) lead time. It was decided arbitrarily that a sample of 300 items from the tape would be sufficient for simulation purposes. Thus for each simulation run a uniformly distributed random sample was drawn from the 3,400 items on the tape by means of a uniform discrete random number generator initialized by a different random number seed for each run. The seeds were selected at random from a table of random numbers.

The six data elements for each of the 300 items selected for a simulation run were used to initialize and compute all required data for the simulations. Unit price, demand and frequency were used to establish initial stocking and

funding policies. The demand and MAD elements were utilized to establish the Stuttering Poisson distribution, which was used, as discussed in Appendix A, to generate ten years of demand history. The lead time was used to arrive at a measure of number of back-orders, number of back-order days, and to set reorder points.

B. GENERAL DESCRIPTION OF MODEL

The simulation model initially selects 300 numbers at random, uniformly distributed between one and 3,400. The six data elements for each 9-COG item on the MSPR tape corresponding to the 300 selected numbers were read from the tape and stored in one of two working matrices; i.e., matrix IDATA for integer data and matrix DATA for decimal data. Since there is a positive probability that the uniform discrete random number generator may generate duplicate numbers, the actual number of items selected was somewhat smaller than 300 but was never smaller than 287 items. At this point one-third of the items previously selected were again subjected to a random, uniform selection to be coded as items of active stock. The remaining two-thirds of the items were held in reserve and coded as not-carried items.

The value of annual demand for all items coded active was then calculated and optimal order quantities for each item were calculated in the parameters calculation subroutine (Subroutine PARAM) under the guidelines of Ref. 1. Safety

levels were then calculated in the safety level computation routine (Subroutine SAFLEV) under the guidelines of Ref. 2. See Appendix B for a discussion of the method of calculating safety levels using λ'.

At this point, a critical assumption of constant lead time was made to facilitate the rapid calculation of reorder points. Contact with the stock point whose data was on the MSPR tape indicated that the lead time data element of the tape contained the most recent lead time experienced by each item. It is that value that was used for the lead time in the simulations.

The next step of the simulation was to calculate the recommended, quarterly VOSL program funding in the funding subroutine (Subroutine BUCKS) under the guidelines of Ref. 3. Since funding is based on dollar value of issues, it was also assumed that the dollar value of demands equals the dollar value of issues. This assumption was applied only to the first four quarters of the simulation since demands and issues were recorded separately once the simulation began. A decision was also made at this point to calculate dollars of fund reduction due to long supply based on the percentage method of Ref. 3 rather than by Stratification.

Recent observations of stock point A indicates that approximately ten percent of their total number of carried items become inactive due to declining demands over a year's time, and approximately the same number of not-carried items qualify for stocking. Based on this observation, at the

beginning of each simulation year, ten percent of the active items were selected to become inactive over the course of the year. Again a random uniform selection as to which quarter of the year each item would become inactive was made, and at the first of the selected quarter, demand was set equal to zero. A similar procedure was followed to select a like number of not-carried items to begin experiencing demand during the selected quarter of the year.

The simulation then used the Stuttering Poisson distribution as a vehicle to calculate time until next demand and quantity of next demand. The use of the Stuttering Poisson is a major assumption which ultimately means that the times between demands are independent, identically distributed as the exponential distribution, and that the quantity demanded is distributed geometrically. Two artificialities were introduced into the simulation; first, time to next demand was constrained to be greater than or equal to one day and second, quantity of demand was constrained to integer values between one and ten thousand to eliminate unrealistically high demands.

In as much as the data elements of the MSPR tape indicated that the inventory position of the majority of the items was less than optimal; the program was designed to allow the user the choice of (1) bringing the inventory position to a point between the reorder point and the requisition objective, or (2) leaving the inventory position "as is" to begin the simulation. This is accomplished by

the insertion/removal of the card calling Subroutine REORDR in the main program. The user of the program also has the option of utilizing the calculated VOSL optimal order quantity, or constraining the order quantity to any desired level by the insertion/removal of cards in the issue subroutine (Subroutine DISSU).

One additional assumption was made concerning unit price of the items. It was assumed that all items were standard stock to be processed at standard price; however, in order to approximate more closely the current economic environment, unit price was increased 2.5 percent the first day of each quarter. The figure of 2.5 percent is based on the current government cost of capital and inflation which is approximately ten percent annually. It is recognized that an increase in unit price of 2.5 percent applied quarterly, biases the annual percentage rate upwards from 10 percent to approximately 10.4 percent. This is not significantly different from the real world situation of fluctuating inflation. However, in the analysis of the simulation results, one can not consider the absolute value of dollar differences alone, but must also consider the percentage of difference between ten year totals of funds vs. sales. These percentages should remain stable since the inflation increases were applied on a constant basis.

In the day to day simulation of ten years of operation the following three principles were used:

1. When a demand is processed, resupply, if required, is initiated immediately, and when an outstanding resupply order is received, outstanding backorders are filled immediately.
2. Receipts are always processed before demands when they occur on the same day.
3. The ten years of simulation are ma on the premise of 30 day months, 91 day quarters and 364 day years.

At this point the 10 year simulation began by comparing the earliest event time where an event was considered to be a demand or receipt of a resupply order. The earliest event was processed in either the receipt of a resupply requisition subroutine (Subroutine RECPT) or the issue subroutine. In Subroutine RECPT, the receipt of the outstanding resupply order was processed, outstanding backorders, when existing, were filled and on hand stock position was updated. In Subroutine DISSUE the demands for stock were filled or back-ordered if the on hand balance was insufficient to meet the demand. Time and quantity of next demand were updated for the item which had completed processing of the current demand and a resupply order was generated when necessary. Two assumptions which were made should be noted at this point. First, there are no lost sales since partial issues are made when the quantity of demand exceeds on hand balance and the unfilled portion of the quantity demanded is placed on backorder. Some exceptions to this assumption were made for the second, third, fourth and fifth type runs discussed in the following section. The assumption was relaxed when and if, on a quarterly basis, the point was reached where the dollar value of the backorder would exceed the remaining

balance of funds available. The items which would have been treated as backorders in this case were counted as lost sales. The second assumption was that stock replenishments were to be computed as multiples of the computed economic VOSL order quantity, q*. A multiplier of q* (an integer value constrained between zero and two hundred) was determined in order to insure that the inventory position was increased to a point between the reorder point and the requisition objective when a resupply action was necessary.

After processing the earliest event in the applicable subroutine, control was returned to the main program where the determination of the next earliest event time was made. A check was made to determine if the current earliest time places the simulation in the next quarter of the year and/or the next simulation year. When the next quarter was reached, Subroutine ENDQTR was called to compute the fund grant for the following quarter, update the changes required in the active/inactive items and compute the value of excess stock on hand. Two additional assumptions were made at this point. First, for items scheduled to be coded inactive, the quantity of demand was set to zero at day one of the quarter in which the item becomes inactive. The on hand quantity was maintained "as is" for three quarters of a year before being set to zero during the fourth quarter of being coded inactive. The rationale behind this time span was obtained from Stock Point A where, in their estimation, it takes two quarters of zero demand to recognize an inactive item;

another quarter to declare the item excess, process required paper work and receive disposition instructions; and sometime in the following (fourth) quarter the stock is removed from inventory. It must be noted that there was no reimbursement of funds to the stock point for excessed items made in the simulation. Based on point A's information concerning reimbursement as a percentage of the inventory value of items excessed and the dollar value of items actually excessed in the simulation there would be no significant effect on the results of the simulation. The second assumption was that when an active coded item did not experience sufficient demand and frequency to remain active, the item was considered to fall in the insurance item category and remained in the inventory as an active item. This assumption appears to be valid since ten percent of the inventory has previously been coded to become inactive during the year (based on the estimate of Stock Point A) and a perusal of the simulation results indicate that an insignificant number of items with low dollar value fall in the insurance item category in any year.

At the end of each simulation year, parameters were recomputed based on the actual simulation issues and demands of the previous four quarters, and a new fund grant was computed for the simulation to continue into the next year.

C. DESCRIPTION OF TRIALS

Five basic types of simulations were run with each type being run three times with different random number seeds to provide results for different data samples.

The first type simulation run was designated "VOSL-RSM OPTIMAL" since all calculations were made optimally as per the guidelines of Refs. 1, 2, and 3. This type run does not attempt to approximate actual happenings at a stock point but attempts to determine what would happen if orders were placed at the appropriate times and for the optimal quantities without being limited by a budget constraint. This is an implicit assumption that if and when additional funds are required for stock replenishment; the additional funds are made available. In as much as the inventory position obtained from the MSPR tape is not optimal, the inventory position was reset to a point between the reorder point and the requisition objective before beginning the time step through the ten years of simulated operation. During the course of the ten years simulated operation, all calculations related to stocking and funding policies were made optimally. The significant points in this type simulation, as in all other types of simulations run, are (1) an inflation factor which increases unit price 2.5% on day one of each quarter, (2) an excessing policy which approximates the current policy in use at Stock Point A, (3) constant lead times, and (4) the use of the STUTTERING POISSON distribution to compute times and quantities of demand. At the completion of ten years of simulated operation, various statistics and data were printed for analysis and comparison.

The second type simulation run was designated "VOSL-RSM MODIFIED". This type run was identical to the first type

except for the following three modifications: (1) the dollar value of resupply orders placed each quarter was constrained to be less than or equal to the available funds, (2) the demand was treated as a lost sale, if and when, in any quarter, there were insufficient funds available to backorder stock to meet an existing demand, and (3) surplus funds were expended on resupply orders if and when surplus funds were available on the last day of the quarter. The significant points as discussed for the first type run remained the same for this type run. At the completion of ten years of simulated operation various statistics and data were again printed for analysis and comparison.

The third type simulation run was designated "MOD" since optimal VOSL stocking policies were not used; however, the method of calculating funds under the VOSL system was maintained. This type run was designed to represent an approximate model of the general policies used at Stock Point A; thus, the inventory position at the beginning of the simulation remained exactly as shown on the MSPR tape. The modifications to the optimal policies for this type run were: (1) resupply orders were constrained in quantity to provide a maximum inventory position of thirty days forecasted demand, (2) the demand was treated as a lost sale if and when, in any quarter, there were insufficient funds available to back-order stock to meet an existing demand, (3) resupply orders were generated only when the inventory position of any item was found to be less than or equal to zero, (4) the surplus

funds were expended on resupply orders if and when, in any quarter, surplus funds were available on the last day of the quarter, and (5) the dollar value of resupply orders placed each quarter was constrained to be less than or equal to available funds. Again the significant points discussed for the first type run remained the same, and at the end of ten years simulated operation, statistics and data were printed for analysis.

The fourth type of simulation run was designated "MOD2". This run was identical to the third type run (MOD) with the exception that the inventory position at the beginning of the simulation run was placed at a point between the reorder point and the requisition objective prior to beginning the time step portion of the run; i.e., there was an initial fix. Everything else in this type run was exactly the same as in the third type run.

The fifth and final type of simulation run was designated "VOSL-RSM MOD2". This run was identical to the second type run (VOSL-RSM MODIFIED) with the exception that the inventory position at the beginning of the simulation run remained exactly as shown on the MSPR tape; i.e., no initial fix. Everything else in this type run was exactly the same as the second type run.

The purpose of the initial fix or initial order to correct inventory position deficiencies was to determine if the one-time expenditure of funds made any significant difference in the end results of the simulations.

FEATURE	TYPE OF RUN				
	VOSL-RSM OPTIMAL	VOSL-RSM MODIFIED	MOD	MOD2	VOSL-RSM MOD2
INFLATION	yes	yes	yes	yes	yes
FUND CONSTRAINT	no	yes	yes	yes	yes
INITIAL ORDER	yes	yes	no	yes	no
VOSL RULES	yes	yes	no	no	yes
POINT A RULES	no	no	yes	yes	no
BACKORDERS	yes	yes	yes	yes	yes
LOST SALES	no	yes	yes	yes	yes

III. ANALYSIS OF SIMULATION RESULTS

Before beginning any type of analysis it seems proper to briefly review the salient points common to all types of simulation runs. These points are:

(1) Constant lead time for each item; however, the lead times are uniformly distributed about the mean due to Stock Point A's procedure of recording most recently observed lead time for each item on the MSPR tape.

(2) Stuttering Poisson process for generating time and quantity of next demand, which implies a constant mean rate of demand over the ten year simulation.

(3) A reasonable excessing policy based on actual practice at Stock Point A.

(4) A fixed inflation factor of 2.5% which increases unit price on a quarterly basis and thus affects both issues and resupply orders.

The results of the five types of simulations described in the previous section are now discussed in turn.

A. VOSL-RSM OPTIMAL

The VOSL-RSM OPTIMAL simulation was designed to determine if the optimal stocking and funding policies are compatible under ideal conditions. This required the dollar value of orders to be unconstrained by funds, but the value of orders versus funds would be compared at the end of the simulation. In addition, this type simulation also provided a base line as to what effectiveness and work load should be under ideal conditions. These measures were:

(1) total number of backorders,

(2) total number of backorder days, and

(3) total number of resupply orders.

The simulation results for the three different inventory samples used in the VOSL-RSM OPTIMAL type simulations showed that, in each case, the value of resupply orders exceeded funds generated. On the average, fund grants were 96.2% of the value of resupply orders and the range of this difference was from 95.1% to 96.8%.

It is recognized that the percentage difference between funds and resupply orders is small, however, any increase in lead times, demand rates, inflation or a less aggressive excessing policy would serve to increase the difference. Even though the percentage difference seems small the magnitude of the difference, which was $17,141, must also be investigated.

Since both the stocking and funding policies operate on the premise of 2.5 months of stock on hand, the value of the on hand inventory can be approximated by calculating the average monthly value of issues (approximately equal to the value of monthly demands for this type simulation) and then multiplying this figure by 2.5 months. This value was calculated to be $9,238. Thus the percentage of difference which initially seemed quite small takes on more significance, and it is clear from the above calculations that the magnitude of the difference represents a value equivalent to a loss of 185.5% of the value of on hand inventory. The range of this loss for the three stock samples was from 154% to 245%. It must be recognized that the small percentage difference or shortfall in fund grants is somewhat misleading.

This is because orders were placed optimally at all times and in the quantities appropriate without regard to available funds. This produced additional on-hand stock which would not have been available under a fund constraint and this additional stock in turn provided the base for increased sales. The increased issues then generated increases in fund grants. Even with this ultra optimistic approach there was still a short fall in fund grants. Recognize also that there is no real loss of inventory, but rather a quantitative measure of the short fall in fund grants.

B. VOSL-RSM MODIFIED

Since the additional funds which would be required to operate the VOSL-RSM OPTIMAL simulation model would not normally be available, the VOSL-RSM MODIFIED simulation was run to determine the effect of constrained funding. This was accomplished by changing the VOSL-RSM OPTIMAL simulation to include the additional constraint that on a quarterly basis, the dollar value of resupply orders must be less than or equal to the dollar value of available funds. The results of this simulation indicated that:

(1) The average funding of the VOSL-RSM MODIFIED simulation was equal to 86.2% of the VOSL-RSM OPTIMAL funding. This 13.8% reduction in fund grants from the VOSL-RSM OPTIMAL simulation is the result of constraining dollar value of resupply orders to be less than or equal to the quarterly fund grants.

This constraint reduced on-hand inventory which in turn reduced sales. The reduced sales then reduced the following quarters fund grants and the cycle of events repeats itself.

(2) Expected number of backorders increased by 62.6%.

(3) Expected number of backorder days increased by 76.4%.

(4) Expected number of stock control type transactions (processing resupply orders plus lost sales) increased by 49.4%. Lost sales were added to orders for determining the increase in transactions, since in the real world supply system the lost sale to VOSL-RSM must still be processed as a direct purchase or passed to another supply activity. Thus a lost sale does increase the work load of the stock control branch.

C. MOD

The third type simulation, designated MOD, approximates the stocking policy in use at Stock Point A and was run to determine the effects of operating under a rather severe factoring of optimal stocking policies. For this type simulation, initial inventory position at the start of the simulation remained as shown on the MSPR tape and there was no initial inventory fix. On a quarterly basis dollar value of resupply orders was constrained to be less than or equal to available funds, and resupply orders were constrained in quantity to allow a maximum inventory position equal to 30 days forecasted demand. In addition, resupply orders

were generated only when inventory position became less than or equal to zero. This is equivalent to a zero reorder point and a negative safety level. The results of this simulation were compared to the VOSL-RSM OPTIMAL simulation results and showed that:

(1) Average funding was reduced to 68.6% of VOSL-RSM OPTIMAL funding. The severe reduction of funds was primarily due to the initial inventory position in which stock was unavailable for issue; thus there was a reduction in issues, which reduced funds, which reduced inventory, etc. With the ultimate end being a drastic reduction in funds.

(2) Expected number of backorders increased by 376.4%.

(3) Expected number of backorder days increased by 354%.

(4) Expected number of stock control type transactions increased by 401.4%.

D. MOD2

The fourth type simulation run, designated MOD2, was designed to correspond directly to the second type simulation (VOSL-RSM MODIFIED) in order to determine the effects of a factored stocking policy. MOD2 is identical to VOSL-RSM MODIFIED with the exception of the stocking policy which was as described for the third type simulation (MOD). In addition, the MOD2 run serves to indicate what would happen if Stock Point A were allowed additional funds in order to bring the existing inventory position to a point between the

reorder point and requisition objective while continuing to operate under their current stocking policy.

The results of this type run indicate that the use of the factored stocking policy had the following effects when compared to VOSL-RSM MODIFIED simulation results:

(1) Average funding increased to 104.4% of VOSL-RSM MODIFIED funding. The average funding increased, because fewer dollars were being placed into inventory by smaller q's and r's for items for which demand declined. Thus the loss due to "bad buys" was reduced. Also, due to the policy of negative safety level, more backorders were generated. This caused more issues to take place in a quarter following the resupply order. Thus, the issue was processed at a price higher than the resupply cost, increasing issues, fund grants, etc.

(2) Expected number of backorders increased 239.1%.

(3) Expected number of backorder days increased 221.0%.

(4) Expected number of stock control type transactions increased 400.5%.

The results of the MOD2 run were also compared to the type three (MOD) simulation to determine the effect of a one-time fund grant used to place the inventory in an optimal position before beginning the simulation. The results of this comparison between the MOD and MOD2 runs are as follows:

(1) Average funding increased to 131.2% of MOD funding. This increase is primarily due to the increased initial inventory position which allowed more issues, increased fund grants, etc.

(2) Expected number of backorders decreased to 81.6% of MOD. This decrease in backorders and backorder days resulted because the initial inventory position fix was utilized to meet demands while available funds were utilized to replenish the on-hand inventory.

(3) Expected number of backorder days decreased to 85.9% of MOD.

(4) Expected number of stock control type transactions increased to 119.4% of MOD. The stock control transactions increased, because the additional funds generated by the increased initial inventory allowed placement of additional orders which, in turn, generated more funds, etc.

E. VOSL-RSM MOD2

The fifth type simulation, designated VOSL-RSM MOD2, was designed to investigate what would happen at Stock Point A if the initial inventory position were not changed from that indicated in the MSPR tape and a VOSL-RSM optimal stocking policy was utilized. This simulation was identical to the second type simulation (VOSL-RSM MODIFIED) except that the initial inventory position was not changed. The results of this simulation were compared with the third type

simulation (MOD) to contrast the difference in the two stocking policies. The results of this comparison are:

(1) Funding decreased to 89.1% of MOD funding. The funds decreased because the VOSL-RSM operates on a requisition effectiveness premise and minimizes all costs which include holding and ordering. Thus, funds are invested in high demand fast moving items, and not necessarily the high dollar value items. But most importantly there was no initial fix to allow more sales and thus generate more funds.

(2) Expected number of backorders decreased to 31.7% of MOD. This decline in backorders and backorder days is due to the basic purpose of the VOSL-RSM model. That is, to minimize the probability of requisitions short.

(3) Expected number of backorder days decreased to 37.2% of MOD.

(4) Expected number of stock control type transactions decreased to 44.3% of MOD.

IV. SUMMARY AND CONCLUSIONS

The computer simulations used in this study attempted to model a very complex, dynamic inventory control system. As is the case with most simulations, short cuts and approximations of reality were used when necessary to reduce computer time. Consequently, one should consider the numerical results of the simulations and analysis on an order-of-magnitude basis only.

The analysis of the results of the VOSL-RSM OPTIMAL simulation runs supports the hypothesis that the existing stocking and funding policies are not operating as designed. Acceptance of this hypothesis in no way constitutes a criticism of either the VOSL-RSM inventory model or the 9-COG funding policy on an individual basis. In fact, when considered separately, the two policies seem to be well grounded theoretically and present a rational approach to solving an extremely complex real world problem. However, when the two policies are mated there is strong evidence from both the results of this simulation as well as from information obtained via informal contacts with several major stock points that there is indeed a significant problem when the two policies are considered collectively.

For example, the three different inventory samples used in the VOSL-RSM OPTIMAL type simulation each showed that fund grants were insufficient to meet the value of the optimal resupply orders. In fact, the difference after

ten years of simulated operations was equivalent to 154% of the value of average on-hand inventory.

The secondary hypothesis, that the inventory position and effectiveness measures of a stock point using local, less than optimal, stocking policies will be much worse than when following VOSL-RSM rules even in an insufficient funds climate, has been well supported by the simulation results. However, the perspective from which one views the results is most critical on this point. For example, a very restrictive locally devised stocking criteria in which only high demand fast moving items are stocked keeps a stock point's net effectiveness high. But this policy does poorly in generating funds. The end result is that net effectiveness looks good while service as perceived by the customer is degraded due to longer waiting times for the not-carried slower moving items.

The simulation results also indicate that when a stock point significantly reduces optimal order quantities and uses a restricted inventory position there is an increase in fund grants. This is caused by the slight increase in sales resulting from small stocks of slower moving items. However, backorders and the internal workload of the stock point increase rapidly when using this type policy.

Since the results of this simulation verify the stock point's contention that funds are insufficient for optimal operation, there is a direct implication that the stock points are forced to operate inefficiently in order to

survive in the short run. This has led to a situation in which the individual stock points ignore or modify VOSL-RSM as they see fit. Thus, system wide, there exists large disparities in stocking criteria, replenishment critera, etc. The tragedy of this situation is that these locally devised criteria in many cases operate in direct, but unknowing, opposition to system goals.

Perhaps the admirable "CAN DO" attitude and spirit of the Navy is catching up with the times, for the fix, patch and make do routines can only be carried on to some point. Maybe the time has come to attack the politically unpalatable problems of proving the Navy needs more funds to combat inflation, bad buys, etc. It is time to face the problems and fight them intelligently with arguments based on sound judgement and objective quantitative analyses.

APPENDIX A. THE STUTTERING POISSON PROCESS

It is assumed that $\{N_i(t),\ t\geq 0\}$ is a Poisson process and that $\{Y_{in},\ n=1,2,\ldots,\ N_i(t)\}$ is a family of independent, identically distributed geometric random variables with probability mass function

$$P_Y(y) = \begin{cases} p(1-p)^{y-1} & \text{for } y = 1,2,\ldots\ldots \\ 0 & \text{elsewhere.} \end{cases}$$

Let Y_{in} be the quantity of item i demanded on requisition n and let $N_i(t)$ be the number of requisitions received up to time t. Additionally, let $X_i(t)$ be the total quantity of item i demanded up to time t. Thus

$$X_i(t) = \sum_{n=1}^{N_i(t)} Y_{in} \quad .$$

The time between arrivals of requisitions for item i is an exponentially distributed random variable, due to the Poisson process assumption, with density function

$$f_T(t) = \begin{cases} \lambda_i e^{-\lambda_i t} & \text{for } t \geq 0 \\ 0 & \text{elsewhere.} \end{cases}$$

A compound Poisson process such as $\{X_i(t),\ t\geq 0\}$ where Y_{in} is geometrically distributed is frequently referred to as a STUTTERING POISSON PROCESS [Ref. 4].

From the MSPR tape, mean quarterly demand (DBAR) and mean absolute deviation of quarterly demand (MAD) were obtained for each item. These parameters were then used to estimate the parameters of the Stuttering Poisson demand distribution for each item in the inventory. Since the simulation time-step is one day, the parameters of the exponentially distributed interarrival time for requisitions must also be expressed in days. Thus mean daily demand, μ_i, is

$$\mu_i = \frac{DBAR_i}{91} \tag{1}$$

The variance of daily demand, σ_i^2 is

$$\sigma_i^2 = \frac{1}{91}\left[\frac{MAD_i}{0.8}\right]^2 , \tag{2}$$

assuming 91 days per quarter and that the standard deviation of quarterly demand is estimated by $MAD_i/0.8$ [Ref. 5].

For a compound Poisson process $\{X_i(t),\ t \geq 0\}$ it can be shown that [Ref. 6]

$$E[X_i(t)] = \lambda_i t\ E[Y_{in}] , \tag{3}$$

$$VAR[X_i(t)] = \lambda_i t\ E[Y_{in}^2] . \tag{4}$$

Since Y_{in} is distributed geometrically, it follows that, when t is set equal to one day, the equations for the mean

and variance of daily demand, μ_i and σ_i^2, are

$$E[X_i(1)] = \frac{\lambda_i}{P_i} = \mu_i \ , \tag{5}$$

$$VAR[X_i(1)] = \frac{\lambda_i(2-P_i)}{P_i^2} = \sigma_i^2 \tag{6}$$

Solving equation (5) yields $\lambda_i = P_i\mu_i$. Substitution of this into equation (6) gives

$$P_i = \frac{2\mu_i}{\sigma_i^2 + \mu_i}$$

and

$$\lambda_i = \frac{2\mu_i^2}{\sigma_i^2 + \mu_i} \ ,$$

where μ_i and σ_i^2 are given by equations (1) and (2).

Thus, in this manner, the STUTTERING POISSON distribution parameters are computed for each item.

APPENDIX B. SAFETY LEVEL CALCULATION METHOD

In VOSL-RSM the inventory is constrained to permit an average on hand investment equal to two and one-half months of supply. The total inventory is comprised of items separated into ten sales classes based on the individual items value of annual demand. In addition the sales class configuration of the inventory determines the average level of operating stock investment, α. Then with this α, there remains $(2.5 - \alpha)$ months of supply which are to be invested in safety stocks.

The total value of the previous years demands (VADSUM) may be easily computed and divided by twelve to provide the estimated or average value of monthly demand. The estimate of dollars required for safety stock investment (DSLA) then may be computed by

$$\text{DSLA} = (\text{VADSUM}/12)\ (2.5 - \alpha)$$

This becomes the funds available for the requisition short model to allocate in such a manner that requisition effectiveness is maximized.

Reference 2 attacks the problem of the requisitions short model by means of a risk equation for computation of risk of stock out. This equation is solved by the method of Lagrange to obtain

$$P_i = \lambda' \left[\frac{C_i \; Q_i}{F_i} \right] \tag{1}$$

and

$$\lambda' = \frac{\sum_{i=1}^{N} \left[\frac{P_i F_i}{Q_i} \right] SL_i}{\left[\frac{2.5-\alpha}{3} \right] \sum_{i=1}^{N} C_i \overline{D}_i} , \tag{2}$$

where

λ' = Lagrange Multiplier
P_i = Risk of a stockout for the i^{th} item
C_i = Unit price of the i^{th} item
F_i = Annual frequency of the i^{th} item
$\overline{D}_i$ = Quarterly Demand Forecast for the i^{th} item
Q_i = The order quantity from the VOSL program for the i^{th} item.
SL_i = Safety level in units for the i^{th} item

Since a direct method of solving equations (1) and (2) is not feasible and the iterative method of solution utilized in Ref. 2 is very time consuming on a computer, an estimate of the exact solution was obtained by linear interpolation as follows:

(a) Select two arbitrary values of λ' and designate them λ'_K ; K=1,2.

(b) Solve equation (1) for all i; K=1,2.

(c) Solve equation (2) in terms of SL_i for all i; K=1,2.

(d) Compute DL_k, the total dollar requirement for safety level investment using λ'_K , where

$$DL_k = \sum_{i=1}^{N} C_i SL_i \qquad ; K=1,2.$$

(e) Compute the linear interpolation estimated solution for λ' where

$$\lambda' = \frac{(DSLA - DL_1)(\lambda'_1 - \lambda'_2)}{(DL_1 - DL_2)} + \lambda'_1$$

This method assumes that by virtue of past experience the two arbitrary values of λ' initially selected would bracket the exact solution to equation (2). It should also be noted the linear interpolation method of estimating the solution to equation (2) (which is assumed to be a convex function) will provide a solution value slightly higher than the exact value. This implies a small increase in risk and corresponding small decrease in the safety level dollar investment.

The final step in computing safety levels by this method is to take the estimated solution for λ' and calculate SL_i for each item in the inventory using equation (2).

APPENDIX C. MATRIX TERMINOLOGY

In the computer simulation, two basic working matrices were used for data storage. Matrix IDATA with an individual data position denoted IDATA (i,j) where i=1,2,..., 300 and j=1,2,...,25 contained integer data for the i^{th} item of stock. The 25 data positions (j) for the individual items of stock are defined as follows:

j	DEFINITION
1	serial number of VOSL item obtained form MSPR tape
2	quantity on hand
3	quantity due
4	quantity backordered
5	reorder point
6	safety level
7	economic order quantity
8	requisition objective
9	lead time demand
10	VOSL stock class
11	quantity demanded quarter prior
12	quantity demanded 2 quarters prior
13	quantity demanded 3 quarters prior
14	quantity demanded 4 quarters prior
15	frequency of demand quarter prior
16	frequency of demand 2 quarters prior
17	frequency of demand 3 quarters prior
18	frequency of demand 4 quarters prior
19	time of next demand
20	quantity of next demand
21	active/inactive item code
22	total frequency prior year
23	active/inactive quarter code
24	quantity requisitioned for resupply
25	time of receipt of next resupply requisition

Matrix DATA with an individual data position denoted DATA (i,j) where i = 1,2,...,300 and j=1,2,...,25 contained real number data for the i^{th} item of stock. The 25 data positions (j) for the individual items of stock are defined as follows:

j	DEFINITION
1	unit price
2	order quantity in months of stock
3	quarterly demand forecast
4	mean absolute deviation of demand (MAD)
5	lead time
6	value on hand inventory
7	value of annual issues
8	the STUTTERING POISSON parameter, V
9	the STUTTERING POISSON parameter, P
10	value of annual demand (VAD)
11	cumulative percent VAD
12	dollar value of quantity ordered
13	total number of backorders per year
14	total number of backorder days per year
15	total number of issues per quarter
16	total number of demands per quarter
17	total number of resupply requisitions per quarter
18	total number of demands processed not carried per quarter
19	total value of demands processed not carried per quarter
20 thru 25	not used for individual item

The position DATA (2,25) was used to maintain a quarterly running balance of funds.

APPENDIX D

TYPE ONE SIMULATICN

VOSL-RSM OPTIMAL

RUN NUMBER	FUND GRANT	VALUE ORDERS	VALUE ISSUES	TOTAL BACKORDERS	TOTAL BACKORDER DAYS	TOTAL NUMBER CRDERS	VALUE INITIAL ORDER
1	621753	642259	636545	1123	31713	2225	8536
2	227213	238848	227872	1438	41853	2827	6473
3	455876	475158	465964	1151	32269	1893	5418
TCTAL	1304842	1356265	1330381	3712	105835	6945	20427
AVERAGE	434947	452088	443460	1237	35278	2315	6809

TYPE TWO SIMULATION

VOSL-RSM MODIFIED

RUN NUMBER	FUND GRANT	VALUE ORDERS	VALUE ISSUES	TOTAL BACKORDERS	TOTAL BACKORDER DAYS	TOTAL NUMBER ORDERS	TOTAL LOST SALES
1	554005	553944	564276	1923	58423	2170	808
2	158444	158406	159283	2439	77022	2919	1392
3	412143	412015	411730	1672	51243	2736	355
TOTAL	1124592	1124365	1135289	6034	186688	7825	2555
AVERAGE	374264	374788	378429	2011	62229	2608	851

NOTE *** VALUE INITIAL ORDER
***
*** SAME AS VOSL-RSM OPTIMAL

TYPE THREE SIMULATION

MOD

RUN NUMBER	FUND GRANT	VALUE ORDERS	VALUE ISSUES	TOTAL BACKORDERS	TOTAL BACKORDER DAYS	TOTAL NUMBER ORDERS	TOTAL LOST SALES
1	380345	380327	382829	6362	175015	6362	6879
2	153193	153162	153489	5994	158592	7200	3398
3	361282	361180	366208	5323	146870	8845	2140
TOTAL	894820	894669	902526	17679	480477	22407	12417
AVERAGE	298273	298223	300842	5893	160159	7469	4139

TYPE FOUR SIMULATICN

MOD2

RUN NUMBER	FUND GRANT	VALUE ORDERS	VALUE ISSUES	TOTAL BACKORDERS	TOTAL BACKORDER DAYS	TOTAL NUMBER ORDERS	TOTAL LOST SALES
1	570310	569592	579948	5690	147988	12808	1107
2	197887	197282	198212	4536	120200	12810	1386
3	405816	405701	413375	4199	144403	12438	1016
TCTAL	1174013	1172575	1191535	14425	412591	38056	3509
AVERAGE	391337	390858	397178	4808	137530	12685	1169

NOTE *** VALUE INITIAL CRDER
***
*** SAME AS VOSL-RSM CPTIMAL

TYPE FIVE SIMULATICN

VOSL-RSM MOD 2

RUN NUMBER	FUND GRANT	VALUE ORDERS	VALUE ISSUES	TOTAL BACKORDERS	TOTAL BACKORDER DAYS	TOTAL NUMBER ORDERS	TOTAL LOST SALES
1	327804	327798	329301	1474	47558	1474	6679
2	144039	144021	142971	2386	76336	2386	2013
3	333369	333322	332508	1751	54782	1902	966
TCTAL	805212	805141	804780	5611	178676	5762	9658
AVERAGE	268404	268380	268260	1870	59558	1920	3219

```
THIS TYPE SIMULATION IS CESIGNATED
VOSL-RSM MODIFIED

N=WORLD SAMPLE SIZE
INO=NUMBER OF ACTIVE ITEMS
VAD1=ACTIVE ITEMS BY VAD
VADSUM=VALUE OF ANNUAL DEMAND
VISS=FYTD VALUE OF ISSUES
FGNT=FYTC FUNDS GRANTED
FUND=QUARTERLY OPTAR
DCLORD=VALUE OF ORDERS
JTEST=TIME TILL NEXT DEMAND
ITEST=TIME TILL NEXT RECEIPT
KQTR=QUARTER COUNTER
KYEAR=YEAR COUNTER
SBUCKS=YEAR SUMATION OF FUNDS
YRISS=TOTAL DOLLAR VALUE ISSUES
YRDMD=TOTAL NUMBER DEMANDS
YRORD=TOTAL DOLLAR VALUE ORDERS
YRNISS=TOTAL NUMBER ISSUES
YRFUND=TOTAL DOLLAR VALUE FUNDS
YRBO=TOTAL NUMEER BACKORDERS
YRBOD=TOTAL NUMBER BACKORDER CAYS
YRIBO=TOTAL NUMBER ITEMS THAT FAD BACKCRDERS
YROOD=NUMBER REQUISITIONS PRCCESSED(RESUPPLY)
SLOP=YEARLY DEMANDS TREATED LCST SALES
GLOP=VALUE DEMANDS TREATED LCST SALES
```

```
C                                                                       C
C                                                                       C
C                                                                       C
C             DIMENSION ARRAYS AND SET CCNSTANTS                        C
C                                                                       C
      DIMENSICN IREC(62)
      DIMENSION IDATA(300,25)
      DIMENSICN DATA(300,25)
      DIMENSICN IRND(300)
      DIMENSION SP(4),PSP(4),QMC(10),VX(4),SM(1C),AREA(10),TAREA(10),VAD
     1(10),VMD(10),DLLS(10)
      DIMENSICN VADI(150)
      DIMENSICN POINT(150,3)
      DIMENSICN IPNX(300)
      DIMENSION RND(300)
      DIMENSICN IOQTY(300,8)
      DIMENSION AVISS(4)
      DATA QMC/1.0,1.5,2.0,2.5,3.0,4.C,5.0,6.0,8.0,12.0/
      LCW=1
      LHI=3400
      IKCUNT=0
      JKCUNT=0
      N=300
      KYR=1
      ITIME=1
      IX1=6374151
      IX2=2146503
      IX3=8100199
      IX4=3352667
      IX5=7437741
      EXCZ=0
      YRISS=0.0
      YRDMD=0.0
      YRCRD=0.0
      YRNISS=0.0
      YRFUND=0.0
      YRBO=0.0
      YRBOD=0.0
      YRIBO=0.0
      YRCOD=0.0
      DO 29 I=1,N
      DC 30 J=1,8
      ICQTY(I,J)=0.0
   30 CONTINUE
   29 CCNTINUE
```

```
C                                                                         C
C                                                                         C
C                 SELECT A UNIFORMLY DISTRIBUTED                          C
C                                                                         C
C                      RANDOM DATA SAMPLE                                 C
C                                                                         C
C                 AND SORT INTO NUMERICAL ORDER                           C
C                                                                         C
C                                                                         C
      CALL SELECT(LOW,LHI,N,IX1,IRND)
      DO 10 I=1,N
      IRNX(I)=I
      RND(I)=FLOAT(IRND(I))
   10 CONTINUE
      CALL SHSORT(RND,IRNX,N)
C                                                                         C
C                                                                         C
C                 READ THE SELECTED DATA SAMPLE                           C
C                                                                         C
C                      FROM THE MSPR TAPE                                 C
C                                                                         C
C                                                                         C
 1111 READ (1,900) IREC
  900 FORMAT (8X,I6,6X,I10,18X,I1,27X,I8,4I6,18X,2I9,6X,5I6,I3,4X,9I6,9I
     13,12X)
      IF(IREC(3).EQ.1) GO TO 2222
      GO TO 1111
 2222 IKOUNT=IKOUNT+1
      DO 6111 J=1,N
      IF(IKOUNT.EQ.RND(J))GO TO 3333
 6111 CONTINUE
      GO TO 1111
 3333 JKOUNT=JKOUNT+1
      IDATA(JKOUNT,1)=IKOUNT
      IDATA(JKOUNT,2)=IREC(4)
      IDATA(JKOUNT,3)=0
      IDATA(JKOUNT,4)=0
      IDATA(JKOUNT,21)=0
      IDATA(JKOUNT,23)=0
      DATA(JKOUNT,12)=0.0
      IDATA(JKOUNT,24)=0
      IDATA(JKOUNT,25)=9999
      DATA(JKOUNT,1)=IREC(2)*0.01
      DATA(JKOUNT,3)=IREC(3)*0.01
      DATA(JKOUNT,4)=IREC(10)*0.01
      DATA(JKOUNT,5)=IREC(16)*0.1
      DATA(JKOUNT,11)=0.0
      DO 6112 J=1,4
```

```
      K=10+J
      KK=22-J
      ICATA(JKOUNT,K)=IREC(KK)
      L=14+J
      LL=31-J
      ICATA(JKOUNT,L)=IREC(LL)
 6112 CONTINUE
      IF(IKCUNT.EQ.RND(N)) GO TO 4444
      GC TO 1111
 4444 INC=JKOUNT/3
      N=JKOUNT
C                                                               C
C                                                               C
C               SELECT THE ITEMS TO BE CODED ACTIVE             C
C                                                               C
C                                                               C
      CALL SELECT(LOW,JKCUNT,INO,IX2,IRND)
      DO 6113 I=1,INO
      IKE=IRND(I)
      ICATA(IKE,21)=1
 6113 CCNTINUE
      ISL=0
      DC 8888 I=1,N
      IF(IDATA(I,21).EQ.1) ISL=ISL+1
 8888 CCNTINUE
      INO=ISL
C                                                               C
C                                                               C
C                 THIS MARKS THE BEGINNING CF EACH              C
C                                                               C
C                       SIMULATION YEAR                         C
C                                                               C
C                                                               C
  129 DC 33 I=1,N
      DATA(I,13)=0.0
      DATA(I,14)=0.0
      VAD1(I)=0.0
   33 CCNTINUE
      SBUCKS=0.0
      SUMDA=0.0
      SUMBO=0.0
      EXCZ=0.0
```

```
C                                                                          C
C                                                                          C
C                    COMPUTE VALUE OF ANNUAL DEMAND                        C
C                                                                          C
C                         FOR ALL ACTIVE ITEMS                             C
C                                                                          C
C                                                                          C
      CALL AVAD(IDATA,DATA,N,VAD1,VADSUM)
      IF(KYR.GT.1) GO TO 6978
      DO 1199 KL=1,4
      AVISS(KL)=VADSUM/4.0
 1199 CONTINUE
 6978 WRITE (6,4501) VADSUM
 4501 FORMAT (' ','VADSUM',F10.3)
      KLINK=INO
      IFINK=0
      DO 98 I=1,N
      IF(VAD1(I).GT.0) IFINK=IFINK+1
   98 CONTINUE
      INO=IFINK
      DO 6114 I=1,INO
      IRND(I)=I
 6114 CONTINUE
      CALL SHSORT(VAD1,IRND,INO)
      DO 6115 I=1,INO
      K=INO-I+1
      L=I-1
      POINT(I,1)=VAD1(K)
      IF(I.EQ.1) GO TO 6116
      POINT(I,2)=POINT(L,2)+POINT(I,1)
      POINT(I,3)=POINT(I,2)/VADSUM
      GO TO 6115
 6116 POINT(I,2)=POINT(I,1)
      POINT(I,3)=POINT(I,2)/VADSUM
 6115 CONTINUE
C                                                                          C
C                                                                          C
C                          COMPUTE PARAMETERS                              C
C                                                                          C
C                                                                          C
      CALL PARAM(POINT,QMC,VADSUM,INO,SM,ALADJ)
      INO=KLINK
      DO 6117 I=1,N
      DO 6118 K=1,10
      KAT=K
      IF(DATA(I,10).GT.SM(K)) GO TO 6119
 6118 CONTINUE
 6119 IDATA(I,10)=KAT
```

```
      DATA(I,2)=CMC(KAT)
      DATA(I,3)=(DATA(I,10)/DATA(I,1))/4
      IDATA(I,7)=((DATA(I,3)/3)*(DATA(I,2))+0.5)
      IF(IDATA(I,7).LE.1) IDATA(I,7)=1
      ICATA(I,9)=(DATA(I,3)/3)*(DATA(I,5))
      DATA(I,6)=IDATA(I,2)*DATA(I,1)
      DATA(I,7)=DATA(I,10)
      IF(DATA(I,3).EQ.0.0) DATA(I,3)=1.0
 6117 CCNTINUE
C                                                                     C
C                                                                     C
C                         COMPUTE SAFETY LEVEL                        C
C                                                                     C
C                                                                     C
      CALL SAFLEV(IDATA,CATA,VADSUM,ALADJ,N)
      VISS=0.0
      FGNT=0.0
      VADSUM=AVISS(1)+AVISS(2)+AVISS(3)+AVISS(4)
C                                                                     C
C                                                                     C
C                     CCMPUTE QUARTERLY FUND GRANT                    C
C                                                                     C
C                                                                     C
      CALL BUCKS(DATA,IDATA,VADSUM,N,VISS,FGNT,FUND)
      FGNT=FUND
      SBUCKS=SBUCKS+FGNT
      CALL INOUT(IDATA,N,IX4,IX5,INO)
      IF(KYR.GT.1) GO TO 229
      DC 6120 I=1,N
      AMU=DATA(I,3)/91
      SIGSQ=((DATA(I,4)/0.8)**2)/91
      DATA(I,8)=(2*(AMU**2))/(SIGSQ+AMU)
      CATA(I,9)=(2*AMU)/(SIGSQ+AMU)
      IF(DATA(I,9).GE.1.0) DATA(I,9)=0.99
      IF(DATA(I,9).LE.0.0) DATA(I,9)=0.01
      IX2=IX2*65539
      AA=0.5+IX2*0.2328306E-9
      IDATA(I,19)=ALOG(AA)/(-DATA(I,8))
      IF(IDATA(I,19).LE.0) GO TO 6122
      GC TO 6121
 6122 ICATA(I,19)=1
 6121 IX3=IX3*65539
      AB=0.5+IX3*0.2328306E-9
      IDATA(I,20)=ALOG(AB)/ALOG(1-DATA(I,9))
      IF(IDATA(I,20).GE.10000) GO TO 6121
      IF(IDATA(I,20).LE.0) GO TO 6121
 6125 IF(IDATA(I,21).EQ.2) GO TO 6123
      IF(IDATA(I,21).GE.4) GO TO 6124
```

```
      GC TO 6120
 6123 IF(IDATA(I,23).EQ.1) GO TO 6124
      GO TO 6120
 6124 ICATA(I,19)=9999
 6120 CONTINUE
C                                                                        C
C                                                                        C
C               RESET INVENTORY PCSITION TO A POINT                      C
C                                                                        C
C                    BETWEEN REORDER POINT AND                           C
C                                                                        C
C                      REQUISITICN OBJECTIVE                             C
C                                                                        C
C                 REMOVE CALL CARC IF THIS IS NOT                        C
C                                                                        C
C                             DESIRED                                    C
C                                                                        C
C                                                                        C
      CALL REORDR(IDATA,CATA,N,FUND,ITIME,DOLORD)
      YRCRD=YRCRD+DOLORD
      WRITE (6,9010) FUND,DCLORD
 9010 FCRMAT (' ','FUND=',F10.2,'VALUE CRDERS=',F10.2)
      WRITE (6,9020) ((IDATA(I,J),J=1,25),I=1,JKCLNT)
 9020 FCRMAT (' ',25I5)
      WRITE (6,9030) ((CATA(I,J),J=1,14),I=1,JKCLNT)
 9030 FCRMAT (' ',14F8.2)
      WRITE (6,8000) ALADJ
 8000 FCRMAT (' ',F15.6)
      DO 9111 J=1,10
 9111 CCNTINUE
  229 KCTR=1
C                                                                        C
C                                                                        C
C                 THIS MARKS THE BEGINNING CF EACH                       C
C                                                                        C
C                       SIMULATICN QUARTER                               C
C                                                                        C
C                                                                        C
 3350 KKCTR=(91*(KQTR))+((KYR-1)*364)
      AVISS(KQTR)=0.0
      DCLCRD=0.0
      DATA(1,25)=0.0
      DATA(2,25)=FUND
      DATA(3,25)=0.0
      DO 4446 I=1,N
      DATA(I,15)=0.0
      DATA(I,16)=0.0
      DATA(I,17)=0.0
```

```
      DATA(I,18)=0.0
      DATA(I,19)=0.0
      DATA(I,1)=1.025*DATA(I,1)
      IF(IDATA(I,21).EQ.1) GO TO 4447
      IF(IDATA(I,21).EQ.2) GO TO 4447
      IF(IDATA(I,21).EQ.4) GO TO 4447
      IF(IDATA(I,21).GE.5) GO TO 4447
      GC TC 4446
 4447 ICATA(I,KQTR+10)=0
      IDATA(I,KQTR+14)=0
 4446 CCNTINUE
C                                                                        C
C                                                                        C
C                         DETERMINE EARLIEST EVENT TIME                  C
C                                                                        C
C                  AND GO TC ISSUE,RECEIPT OR ENC QUARTER                C
C                                                                        C
C                        ROUTINES AS APPROPRIATE                         C
C                                                                        C
C                                                                        C
 3349 JTEST=9999
      ITEST=9999
      JJJ=0
      III=0
      DO 3340 I=1,N
      IF(IDATA(I,21).EQ.3) GO TO 3340
      IF(IDATA(I,21).EQ.0) GO TO 3340
 3341 IF(JTEST.LE.IDATA(I,19)) GO TO 3342
      JTEST=ICATA(I,19)
      JJJ=I
 3342 IF(ITEST.LE.IDATA(I,25)) GO TO 3340
      ITEST=IDATA(I,25)
      III=I
 3340 CCNTINUE
      KILL=ITEST-JTEST
      IF(KILL.GE.0) GO TO 3344
      IF(KKQTR.GE.ITEST) GO TO 3345
      GC TO 3346
 3344 IF(KKQTR.GE.JTEST) GO TO 3347
```

```
C                                                                       C
C                                                                       C
C                PERFCRM END QUARTER HOUSEKEEPING                       C
C                                                                       C
C                       COMPUTATIONS                                    C
C                                                                       C
C                                                                       C
 3346 ITIME=KKQTR
      KLIK=0
    6 DO 1 I=1,N
      IF(DATA(2,25).LE.5.0) GO TO 7
      IF(IDATA(I,21).EQ.1) GO TO 2
      IF(IDATA(I,21).EQ.2) GO TO 2
      GC TO 1
    2 IWAN=IDATA(I,2)+IDATA(2,3)-IDATA(I,4)
      IF(IWAN.LE.KLIK) GO TO 3
      GC TO 1
    3 IF(DATA(2,25).GE.DATA(I,1)) GO TO 4
      GC TO 1
    4 DCLORD=DCLORD+DATA(I,1)
      DATA(2,25)=DATA(2,25)-DATA(I,1)
      DATA(I,17)=DATA(I,17)+1.0
      IF(IDATA(I,3).EQ.0) GO TO 5
      ICATA(I,3)=IDATA(I,3)+1
      GC TO 1
    5 IDATA(I,25)=ITIME+(30.0*DATA(I,5))
      ICATA(I,3)=IDATA(I,3)+1
    1 CCNTINUE
      IF(KLIK.GT.99) GO TO 7
      KLIK=KLIK+1
      IF(DATA(2,25).GT.5.0) GO TO 6
    7 WRITE (6,142) DOLORD
  142 FCRMAT(' ','DOLORD',F10.2)
      YRORD=YRORD+DOLORD
 1781 SLCP=0.0
      GLCP=0.0
      DO 1782 I=1,N
      SLCP=SLCP+DATA(I,18)
      GLOP=GLOP+(DATA(I,19))
 1782 CCNTINUE
      WRITE (6,1783) SLOP,GLOP
 1783 FORMAT (' ','DUE TO INSUFF FUNDS',F16.2,'ISSUES WERE LOST WHICH WE
     1RE VALUED AT',F16.2)
      IF(KQTR.EQ.4) GO TO 3348
      DC 8813 I=1,N
      CATA(I,6)=IDATA(I,2)*DATA(I,1)
 8813 CCNTINUE
```

```
      CALL ENDQTR(IDATA,DATA,N,SM,QMC,VACSUM,AVISS,FGNT,FUND,VALUE,VISS,
     1KCTR,IX2,IX3,INO,EXCZ,ITIME)
      SBUCKS=SBUCKS+FUND
      DO 2929 I=1,N
      YRNISS=YRNISS+DATA(I,15)
      YRDMD=YRDMD+DATA(I,16)
      YROOD=YROOD+DATA(I,17)
 2929 CONTINUE
      GO TO 3350
C                        PERFORM END YEAR HOUSEKEEPING                 C
C                                    COMPUTATIONS                      C
 3345 ITIME=ITEST
      CALL RECPT(IDATA,DATA,III,IOQTY,AVISS,KQTR)
      GO TO 3349
 3347 ITIME=JTEST
      CALL DISSU(IDATA,DATA,JJJ,ICQTY,KQTR,ITIME,IX2,IX3,AVISS,DOLORD)
      GO TO 3349
 3348 KYR=KYR+1
      DO 7710 I=1,N
      IF(IDATA(I,21).EQ.0) GO TO 7710
      IF(IDATA(I,21).EQ.1) GO TO 7710
      IF(IDATA(I,21).EQ.2) GO TO 7711
      IF(IDATA(I,21).EQ.3) GO TO 7713
      IF(IDATA(I,21).GE.8) GO TO 7710
      GO TO 7712
 7711 IF(IDATA(I,23).EQ.KQTR) GO TO 7714
      GO TO 7710
 7714 IDATA(I,21)=4
      IDATA(I,19)=9999
      IDATA(I,20)=0
      GO TO 7710
 7712 IDATA(I,21)=IDATA(I,21)+1
      IF(IDATA(I,21).LT.7) GO TO 7710
      EXCZ=EXCZ+(IDATA(I,2)*DATA(I,1))
      IDATA(I,2)=0
      IDATA(I,3)=0
      IDATA(I,4)=0
      IDATA(I,24)=0
      IDATA(I,25)=9999
      INO=INO-1
      GO TO 7710
 7713 IF(IDATA(I,23).EQ.KQTR) GO TO 7715
      GO TO 7710
 7715 IX2=IX2*65539
      AAA=0.5+IX2*0.2328306E-9
      IDUM21=ALOG(AAA)/(-DATA(I,8))
      IDATA(I,19)=IDUM21+ITIME
      IF(IDATA(I,19).LE.ITIME) IDATA(I,19)=ITIME+1
```

```
      IDATA(I,21)=1
 7716 IX3=IX3*65539
      AAB=0.5+IX3*0.2328306E-9
      IDATA(I,20)=ALOG(AAB)/ALOG(1-DATA(I,9))
      IF(IDATA(I,20).GE.10000) GO TO 7716
      IF(IDATA(I,20).LE.0) GO TO 7716
 7710 CONTINUE
      WRITE(6,118) KQTR,EXCZ
  118 FORMAT(' ','EXCESS AT END QTR',I3,3X,'IS',F10.2)
C                                                                       C
C                                                                       C
C                            PRINT END YEAR RESULTS                     C
C                                                                       C
C                                                                       C
      WRITE (6,9031) (AVISS(I),I=1,4)
 9031 FCRMAT(' ','AVISS',4F10.2)
      YRISS=YRISS+AVISS(1)+AVISS(2)+AVISS(3)+AVISS(4)
      ARIP=0.0
      DC 4329 I=1,N
      YRNISS=YRNISS+DATA(I,15)
      YRDMD=YRDMD+DATA(I,16)
      YRCCD=YROOD+DATA(I,17)
      IF(DATA(I,13).GT.0.0) ARIP=ARIP+1
      SUMDA=SUMDA+DATA(I,14)
      SLMBO=SUMBO+DATA(I,13)
 4329 CONTINUE
      WRITE(6,2943) SUMBO
 2943 FCRMAT('0','TOTAL NUMBER BACKORCERS FOR THE YEAR IS',9X,F10.2)
      WRITE(6,2843) SUMDA
 2843 FCRMAT(' ','TOTAL NUMBER BACKORDER DAYS FOR THE YEAR IS',F15.2)
      YRFUND=YRFUND+SBUCKS
      YRBO=YRBO+SUMBO
      YRBOD=YRBOD+SUMDA
      YRIBO=YRIBO+ARIP
      WRITE (6,9050) YRDMD,YRNISS,YROOD
 9050 FCRMAT (' ','TOTAL NR DMD=',F16.2,'TOTAL NR ISSUES=',F16.2,'TOTAL
     1NR ORDERS=',F16.2)
      WRITE (6,9060) YRFUND,YRORD,YRISS
 9060 FCRMAT (' ','TOTAL FUND GRANT TO CATA=',F16.2,'TOTAL VALUE ORDERS=
     1',F16.2,'TOTAL VALUE ISSUES=',F16.2)
      WRITE (6,9070) YRIBO,YRBO,YRBOD
 9070 FORMAT (' ','TOTAL ITEMS BO=',F10.2,'TOTAL NR BO=',F10.2,'TOTAL BO
     1 DAYS=',F16.2)
      IF(KYR.EQ.11) GO TO 128
      GO TO 129
  128 STCP
      END
```

```
      SUBROUTINE SELECT(LOW,LHI,N,IX,IRND)
      DIMENSION IRND(300)
      DO 150 I=1,N
      IX=IX*65539
      R=0.5+IX*0.2328306E-9
      IRND(I)=LHI*R+LOW
  150 CONTINUE
      RETURN
      END



      SUBROUTINE AVAD(IDATA,DATA,N,VAD1,VADSUM)
      DIMENSION IDATA(300,25)
      DIMENSION DATA(300,25)
      DIMENSION VAD1(150)
      KK=0
      VADSUM=0.0
      DO 101 I=1,N
      ISUM=0
      DO 201 J=1,4
      K=J+10
      ISUM=ISUM+IDATA(I,K)
  201 CONTINUE
      DATA(I,10)=ISUM*DATA(I,1)
      IF(IDATA(I,21).EQ.1) GO TO 301
      IF(IDATA(I,21).EQ.2) GO TO 301
      IF(IDATA(I,21).EQ.4) GO TO 301
      IF(IDATA(I,21).EQ.5) GO TO 301
      IF(IDATA(I,21).EQ.6) GO TO 301
      GO TO 101
  301 VADSUM=VADSUM+DATA(I,10)
      IF(DATA(I,10).EQ.0.0) GO TO 101
      KK=KK+1
      VAD1(KK)=DATA(I,10)
  101 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE PARAM(POINT,QMC,CS,INO,SM,ALADJ)
      DIMENSION POINT(150,3)
      DIMENSION SP(4),PSP(4),QMC(10),VX(4),SM(10),AREA(10),TAREA(10),VAD
     1(10),VMD(10),DLLS(10)
      ENCP=FLOAT(INO)
      ALPHA=0.7
      MARK1=INO-3
      MARK2=INO-4
      SP(1)=POINT(4,1)
      SP(2)=POINT(MARK2,1)
      SP(3)=POINT(3,1)
      SP(4)=POINT(MARK1,1)
      PSP(1)=POINT(4,3)
      PSP(2)=POINT(MARK2,3)
      PSP(3)=POINT(3,3)
      PSP(4)=POINT(MARK1,3)
      WRITE (6,4551) (SP(I),I=1,4)
 4551 FORMAT (' ','SP',F10.3)
      WRITE (6,4552) (PSP(I),I=1,4)
 4552 FORMAT (' ','PSP',F10.3)
  104 DO 100 K1=1,4
      P1=PSP(K1)
      CALL NDTRI (P1,X,D,IER)
      VX(K1)=X
  100 CONTINUE
      WRITE (6,4553) (VX(I),I=1,4)
 4553 FORMAT (' ','VX',4F10.3)
      RHO2=(ALOG(SP(4))-ALOG(SP(3)))/(VX(3)-VX(4))
      WRITE (6,4554) RHO2
 4554 FORMAT (' ','RHO2',F10.4)
      FLMN2=(VX(2)*ALOG(SP(1))-VX(1)*ALOG(SP(2)))/(VX(2)-VX(1))
      CD=CS/ENCP
      ENLT=6/(EXP((RHO2**2)/8)*SQRT(CD))
      WRITE (6,4555) FLMN2,ENLT
 4555 FORMAT (' ','FLMN2',F10.4,'ENLT',F10.4)
      AQ=ALPHA/ENLT
      DO 200 K2=1,9
      SM(K2)=(6*AQ*((QMC(K2+1)+QMC(K2))/(QMC(K2+1)*QMC(K2))))**2
      WRITE(6,4556)SM(K2)
 4556 FORMAT(' ','SM',F10.3)
      TEE=(ALOG(SM(K2))-FLMN2)/RHO2
      WRITE (6,4557) TEE
 4557 FORMAT (' ','TEE',F10.3)
      CALL NDTR(TEE,P2,D)
      AREA(K2)=1-P2
  200 CONTINUE
      SM(10)=0
      TAREA(10)=P2
```

```
      TAREA(1)=AREA(1)
      DO 300 K3=2,9
      TAREA(K3)=AREA(K3)-AREA(K3-1)
  300 CCNTINUE
      TVAD=0
      TCLLS=0
      TVMD=0
      DC 400 K4=1,10
      VAD(K4)=TAREA(K4)*CS
      VMD(K4)=VAD(K4)/12
      TVAD=TVAD+VAD(K4)
      TVMD=TVMD+VMD(K4)
      DLLS(K4)=VMD(K4)*(QMC(K4))/2
      TDLLS=TDLLS+DLLS(K4)
  400 CONTINUE
  105 ALADJ=TDLLS*12/CS
      RETURN
      END


      SLBROUTINE SAFLEV(IDATA,DATA,VADSUM,ALADJ,N)
      DIMENSION IDATA(300,25)
      DIMENSION DATA(300,25)
      AMDAA=0.003
      AMDAB=0.009
      DSLA=(2.5-ALADJ)*(VADSUM/12)
      TATA=0.0
      TCTB=0.0
  800 DC 810 I=1,N
      JSUMF=0
      DO 825 J=15,18
      JSUMF=JSUMF+IDATA(I,J)
  825 CCNTINUE
      IF(JSUMF.LE.1) JSUMF=1
      IDATA(I,22)=JSUMF
      IF(IDATA(I,21).EQ.1) GO TO 815
      IF(IDATA(I,21).EQ.2) GC TO 815
      IF(IDATA(I,21).EQ.4) GO TO 815
      IF(IDATA(I,21).EQ.5) GO TO 815
      GO TO 810
  815 RHCA=(AMDAA*DATA(I,1)*IDATA(I,7))/JSUMF
      TA=(AMDAA*(2.5-ALADJ)*(DATA(I,1)**2)*DATA(I,3)*IDATA(I,7))/(3*RHOA
     1*JSUMF)
      TCTA=TOTA+TA
```

```
      RHOB=(AMDAB*DATA(I,1)*IDATA(I,7))/JSUMF
      TB=(AMDAB*(2.5-ALADJ)*(DATA(I,1)**2)*DATA(I,3)*IDATA(I,7))/(3*RHOB
     1*JSUMF)
      TOTB=TOTB+TB
  810 CONTINUE
      ZOOM=DSLA-TOTB
      IF(ZOOM.EQ.0.0) ZOOM=1.0
      ZAAM=TOTA-TOTB
      IF(ZAAM.EQ.0.0) ZAAM=1.0
      AMDAC=(ZOOM*(AMDAA-AMDAB)/ZAAM)+AMDAB
      WRITE (6,811) AMDAC
  811 FORMAT (' ','AMDAC',F10.6)
  830 DO 835 I=1,N
  840 RHOC=(AMDAC*DATA(I,1)*IDATA(I,7))/IDATA(I,22)
      IDATA(I,6)=(AMDAC*(2.5-ALADJ)*DATA(I,1)*DATA(I,3)*IDATA(I,7))/(3*R
     1HOC*IDATA(I,22))
      IF(IDATA(I,6).LE.0) GO TO 845
      GO TO 850
  845 IDATA(I,6)=0
  850 IDATA(I,5)=IDATA(I,6)+IDATA(I,9)
      IDATA(I,8)=IDATA(I,6)+IDATA(I,7)
  835 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE BUCKS(DATA,IDATA,VALUE,N,VISS,FGNT,FUND)
      DIMENSION IDATA(300,25)
      DIMENSION DATA(300,25)
      IVAL=0
  510 DO 500 I=1,N
      IF(IDATA(I,21).EQ.1) GO TO 515
      IF(IDATA(I,21).EQ.2) GO TO 515
      IF(IDATA(I,21).EQ.4) GO TO 515
      IF(IDATA(I,21).EQ.5) GO TO 515
      IF(IDATA(I,21).EQ.6) GO TO 515
      GO TO 500
  515 IVAL=IVAL+DATA(I,6)
  500 CONTINUE
      TEST=((12*IVAL)/VALUE)-2.5
      IF(TEST.LT.0.49) GO TO 516
      IF(TEST.LT.0.99) GO TO 517
      IF(TEST.LT.1.49) GO TO 518
      IF(TEST.LT.1.99) GO TO 519
      IF(TEST.LT.2.49) GO TO 520
      IF(TEST.LT.2.99) GO TO 521
      IF(TEST.LT.3.49) GO TO 522
      CENT=0.21
      GO TO 523
  516 CENT=0.0
      GO TO 523
  517 CENT=0.03
      GO TO 523
  518 CENT=0.06
      GO TO 523
  519 CENT=0.09
      GO TO 523
  520 CENT=0.12
      GO TO 523
  521 CENT=0.15
      GO TO 523
  522 CENT=0.18
  523 EXCESS=CENT*(VALUE/4)
      FUND=VISS-EXCESS-FGNT+(VALUE/4)
      WRITE(6,524) EXCESS
  524 FORMAT(' ','EXCESSES REDUCED FUND GRANT',F10.2)
      RETURN
      END
```

```
      SUBROUTINE INOUT(IDATA,N,IX4,IX5,INO)
      DIMENSION IDATA(300,25)
      IDUM1=0.1*INO
      DO 600 K=1,IDUM1
      DO 610 I=1,N
      L=I
      IF(IDATA(I,21).EQ.1) GO TO 615
  610 CONTINUE
  615 IX4=IX4*65539
      R=0.5+IX4*0.2328306E-9
      J=4.0*R+1.0
      IDATA(L,23)=J
      IDATA(L,21)=2
      IF(J.GT.1) GO TO 600
      IDATA(L,19)=9999
      IDATA(L,20)=0
      IDATA(L,21)=4
  600 CONTINUE
      IDUM2=IDUM1
      DO 620 KK=1,IDUM2
      DO 625 II=1,N
      LL=II
      IF(IDATA(II,21).EQ.0) GO TO 630
  625 CONTINUE
  630 IX5=IX5*65539
      RR=0.5+IX5*0.2328306E-9
      JJ=4.0*RR+1.0
      IDATA(LL,23)=JJ
      IDATA(LL,21)=3
      IF(IDATA(LL,23).EQ.1) GO TO 631
      GO TO 620
  631 IDATA(LL,21)=1
  620 CONTINUE
      INO=INO+IDUM2
      RETURN
      END
```

```
      SLBROUTINE REORDR(IDATA,DATA,N,FUND,ITIME,DCLORD)
      DIMENSICN IDATA(300,25)
      DIMENSICN DATA(300,25)
      DCLORD=0.0
      DC 401 I=1,N
      IF(IDATA(I,21).EQ.1) GO TO 402
      IF(IDATA(I,21).EQ.2) GO TO 402
      IF(IDATA(I,21).EQ.4) GC TO 402
      ICATA(I,24)=0
      DATA(I,12)=0.0
      ICATA(I,25)=9999
      GC TO 401
  4C2 IF(IDATA(I,2).LE.ICATA(I,5)) GO TC 403
      ICATA(I,24)=0
      DATA(I,12)=U.0
      ICATA(I,25)=9999
      GO TO 401
  403 DC 404 J=1,20
      ICPB=J*IDATA(I,7)
      NCTY=IOPB+IDATA(I,2)
      IF(NQTY.GT.ICATA(I,5)) GO TO 405
  404 CCNTINUE
  405 ICATA(I,24)=ICPB
      DATA(I,12)=DATA(I,1)*ICPB
      DCLCRD=DCLORD+DATA(I,12)
      ICATA(I,3)=IDATA(I,3)+IDATA(I,24)
      IDATA(I,25)=ITIME+DATA(I,5)*30.0
  401 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE RECPT(IDATA,DATA,III,ICQTY,AVISS,KQTR)
      DIMENSION IDATA(300,25)
      DIMENSION DATA(300,25)
      DIMENSION IOQTY(300,8)
      DIMENSION AVISS(4)
      IDATA(III,2)=IDATA(III,2)+IDATA(III,3)
 9098 IF(IOQTY(III,2).EQ.0) GO TO 3410
      IDATA(III,3)=IOQTY(III,2)
      IDATA(III,25)=IOQTY(III,1)
      IDATA(III,24)=IDATA(III,3)
      DO 3411 I=3,7,2
      K=I+1
      J=I-2
      L=I-1
      IF(IOQTY(III,K).EQ.0) GO TO 3412
      IOQTY(III,J)=IOQTY(III,I)
      IOQTY(III,L)=IOQTY(III,K)
 3411 CONTINUE
      IOQTY(III,8)=0
      IOQTY(III,7)=9999
      GO TO 3413
 3410 IDATA(III,3)=0
      IDATA(III,24)=0
      IDATA(III,25)=9999
      GO TO 3413
 3412 IOQTY(III,J)=9999
      IOQTY(III,L)=0
 3413 IF(IDATA(III,4).EQ.0) GO TO 3416
      IDUM3=IDATA(III,2)-IDATA(III,4)
      IF(IDUM3.LT.0) GO TO 3415
      AVISS(KQTR)=AVISS(KQTR)+(IDATA(III,4)*DATA(III,1))
      DATA(III,15)=DATA(III,15)+1.0
      IDATA(III,2)=IDUM3
      IDATA(III,4)=0
      GO TO 3416
 3415 AVISS(KQTR)=AVISS(KQTR)+(IDATA(III,2)*DATA(III,1))
      DATA(III,15)=DATA(III,15)+1.0
      IDATA(III,2)=0
      IDATA(III,4)=(-IDUM3)
 3416 RETURN
      END
```

```
      SUBROUTINE DISSU(IDATA,DATA,JJJ,IOQTY,KQTR,ITIME,IX2,IX3,AVISS,DOL
     1ORD)
      DIMENSION IDATA(300,25)
      DIMENSION DATA(300,25)
      DIMENSION IOQTY(300,8)
      DIMENSION AVISS(4)
 3365 KKONT=KQTR+14
      KKKONT=KQTR+10
      IDATA(JJJ,KKONT)=IDATA(JJJ,KKONT)+1
      IDATA(JJJ,KKKONT)=IDATA(JJJ,KKKONT)+IDATA(JJJ,20)
      DATA(JJJ,16)=DATA(JJJ,16)+1.0
      IDUM4=IDATA(JJJ,2)-IDATA(JJJ,20)
 8088 IF(IDUM4.LE.0) GO TO 3360
      IDATA(JJJ,2)=IDUM4
      AVISS(KQTR)=AVISS(KQTR)+(DATA(JJJ,1)*IDATA(JJJ,20))
      DATA(JJJ,15)=DATA(JJJ,15)+1.0
      IDATA(JJJ,20)=0
      GO TO 3361
 1773 IX2=IX2*65539
      AA=0.5+IX2*0.2328306E-9
      IDUM8=ALOG(AA)/(-DATA(JJJ,8))
      IDATA(JJJ,19)=IDUM8+ITIME
      IF(IDATA(JJJ,19).LE.ITIME) IDATA(JJJ,19)=ITIME+1
 3369 IX3=IX3*65539
      AB=0.5+IX3*0.2328306E-9
      IDATA(JJJ,20)=ALOG(AB)/ALOG(1.0-DATA(JJJ,9))
      IF(IDATA(JJJ,20).GE.10000) GO TO 3369
      IF(IDATA(JJJ,20).LE.0) GO TO 3369
      GO TO 8091
 3360 IF(IDATA(JJJ,2).EQ.0) GO TO 3361
      AVISS(KQTR)=AVISS(KQTR)+(DATA(JJJ,1)*IDATA(JJJ,2))
      DATA(JJJ,15)=DATA(JJJ,15)+1.0
      IDATA(JJJ,2)=0
      IDATA(JJJ,20)=(-IDUM4)
 3361 DO 3362 I=1,200
      K=I-1
      IDUM5=K*IDATA(JJJ,7)
      IDUM10=IOQTY(JJJ,2)+IOQTY(JJJ,4)+IOQTY(JJJ,6)+IOQTY(JJJ,8)
      IDUM6=(IDUM5-IDATA(JJJ,4))+(IDATA(JJJ,3)+IDUM10)+IDATA(JJJ,2)
      IF(IDUM6.GT.IDATA(JJJ,5)) GO TO 1772
 3362 CONTINUE
 1772 COST=IDUM5*DATA(JJJ,1)
      IF(COST.GT.DATA(2,25)) GO TO 1881
 1776 DOLORD=DOLORD+COST
      IDATA(JJJ,4)=IDATA(JJJ,4)+IDATA(JJJ,20)
      IF(COST.EQ.0.0) GO TO 1771
      DATA(JJJ,17)=DATA(JJJ,17)+1.0
      DATA(JJJ,13)=DATA(JJJ,13)+1.0
```

```
      IF(IDATA(JJJ,24).EQ.0) GO TO 3359
      DATA(JJJ,14)=DATA(JJJ,14)+(IDATA(JJJ,25)-IDATA(JJJ,19))
      GO TO 1771
 3359 DATA(JJJ,14)=DATA(JJJ,14)+DATA(JJJ,5)*30.0
 1771 DATA(2,25)=DATA(2,25)-COST
      IF(IDATA(JJJ,3).GT.0) GO TO 3364
      IDATA(JJJ,3)=IDUM5
      IDATA(JJJ,25)=(30.0*DATA(JJJ,5))+ITIME
      GO TO 1773
 3364 DO 3366 I=2,8,2
      KKK=I
      IF(IOQTY(JJJ,KKK).EQ.0) GO TO 3367
 3366 CONTINUE
      IOQTY(JJJ,KKK)=IOQTY(JJJ,KKK)+IDUM5
      GO TO 1773
 3367 IOQTY(JJJ,KKK)=IDUM5
      KKT=KKK-1
      IOQTY(JJJ,KKT)=(30.0*DATA(JJJ,5))+ITIME
      GO TO 1773
 1744 IDATA(JJJ,4)=IDATA(JJJ,4)+IDATA(JJJ,20)
      GO TO 1773
 1881 COST=DATA(JJJ,1)*IDATA(JJJ,20)
      IDUM5=IDATA(JJJ,20)
      IF(COST.GT.DATA(2,25)) GO TO 1774
      GO TO 1776
 1774 DATA(JJJ,18)=DATA(JJJ,18)+1.0
      DATA(JJJ,19)=DATA(JJJ,19)+COST
      DATA(JJJ,16)=DATA(JJJ,16)-1.0
      IDATA(JJJ,KKCNT)=IDATA(JJJ,KKCNT)-1
      IDATA(JJJ,KKKONT)=IDATA(JJJ,KKKONT)-IDATA(JJJ,20)
      IF(DATA(3,25).GT.0.0) GO TO 1773
      WRITE(6,8092) ITIME,DATA(2,25)
 8092 FORMAT (' ','TIME OF FUND DEPLETION=',I5,'FUND BALANCE IS',F16.2)
      DATA(3,25)=1.0
      GO TO 1773
 8091 RETURN
      END
```

```
      SUBROUTINE ENDQTR(IDATA,DATA,N,SM,QMC,VADSUM,AVISS,FGNT,FUND,VALUE
     1,VISS,KQTR,IX2,IX3,INO,EXCZ,ITIME)
      DIMENSION IDATA(300,25)
      DIMENSION DATA(300,25)
      DIMENSION AVISS(4)
      DIMENSION SM(10)
      DIMENSION QMC(10)
      VALUE=0.0
      IZCOM=KQTR+1
      DO 3374 I=1,4
      VALUE=VALUE+AVISS(I)
 3374 CONTINUE
      VISS=0.0
      DO 3375 I=1,KQTR
      VISS=VISS+AVISS(I)
 3375 CONTINUE
      IF(KQTR.GT.1) GO TO 133
      WRITE(6,9032) KQTR,FUND
 9032 FORMAT(' ','FUND QTR',I3,3X,'IS',F10.2)
  133 CALL BUCKS(DATA,IDATA,VALUE,N,VISS,FGNT,FUND)
      FGNT=FGNT+FUND
      DO 3376 I=1,N
      IF(IDATA(I,21).EQ.0) GO TO 3376
      IF(IDATA(I,21).EQ.1) GO TO 3376
      IF(IDATA(I,21).EQ.2) GO TO 3377
      IF(IDATA(I,21).EQ.3) GO TO 3379
      IF(IDATA(I,21).GE.8) GO TO 3376
      GO TO 3378
 3377 IF(IDATA(I,23).EQ.IZOOM) GO TO 3380
      GO TO 3376
 3380 IDATA(I,21)=4
      IDATA(I,19)=9999
      IDATA(I,20)=0
      GO TO 3376
 3378 IDATA(I,21)=IDATA(I,21)+1
      IF(IDATA(I,21).LT.7) GO TO 3376
      EXCZ=EXCZ+(IDATA(I,2)*DATA(I,1))
      IDATA(I,2)=0
      IDATA(I,3)=0
      IDATA(I,4)=0
      IDATA(I,24)=0
      IDATA(I,25)=9999
      IF(IDATA(I,21).GT.6) INO=INO-1
      GO TO 3376
 3379 IF(IDATA(I,23).EQ.IZOOM) GO TO 3381
      GO TO 3376
 3381 IX2=IX2*65539
      AAA=0.5+IX2*0.2328306E-9
```

```
      IDUM21=ALOG(AAA)/(-DATA(I,8))
      IDATA(I,19)=IDUM21+ITIME
      IF(IDATA(I,19).LE.ITIME) IDATA(I,19)=ITIME+1
      IDATA(I,21)=1
 3382 IX3=IX3*65539
      AAB=0.5+IX3*0.2328306E-9
      IDATA(I,20)=ALOG(AAB)/ALOG(1-DATA(I,9))
      IF(IDATA(I,20).GE.10000) GO TO 3382
      IF(IDATA(I,20).LE.0) GO TO 3382
 3376 CONTINUE
      WRITE(6,134)KQTR,EXCZ
  134 FORMAT(' ','EXCESS AT END QTR',I3,3X,'IS',F10.2)
      KQTR=KQTR+1
      WRITE (6,9032) KQTR,FUND
      RETURN
      END
```

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10. CDR. J. P. Dowling, SC, USN 1
Operations Analysis Branch
Ships Parts Control Center
Mechanicsburg, Pennsylvania 17055

11. CDR. P. F. McNall, SC, USN 1
Code 94
Fleet Material Support Office
Mechanicsburg, Pennsylvania 17055

12. LCDR J. U. Dell, SC, USN 1
Code 97
Fleet Material Support Office
Mechanicsburg, Pennsylvania 17055

13. LCDR R. D. Perkins, SC, USN 1
SUP 04511
Naval Supply Systems Command
Washington, D.C.

14. LCDR R. E. Lewis, SC, USN 1
Naval Supply Center
937 North Harbor Drive
San Diego, California 92132

15. LCDR E. L. Barnes 1
Code 51
Naval Supply Center
937 North Harbor Drive
San Diego, California 92132

16. LCDR E. J. Shields 1
Naval Supply Center
Norfolk, Virginia 23512

17. LCDR W. T. Lee 1
Naval Supply Center
Oakland, California 94625

18. CDR J. R. Davis 1
Code 6300
Naval Air Station
Point Mugu, California 93042

19. LCDR F. L. Meyer 1
Naval Supply Center
Charleston, South Carolina 29411

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
An Investigation of Variable Operating and Safety Level (VOSL) Stocking and Funding Policy

5. TYPE OF REPORT & PERIOD COVERED
Master's Thesis;
March 1974

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
Richard Earl Lewis
Robert Darol Perkins

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Naval Postgraduate School
Monterey, California 93940

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS
Naval Postgraduate School
Monterey, California 93940

12. REPORT DATE
March 1974

13. NUMBER OF PAGES
74

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)
Naval Postgraduate School
Monterey, California 93940

15. SECURITY CLASS. (of this report)
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)
Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
VOSL
Requisitions Short
Simulation
9-COG Funding

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
Control in the management of stocks of retail material (DSA) at Navy stock points is exercised through a centrally administered stocking policy model (VOSL) and funding policy. The dynamic behavior of these controls operating on a stock point was investigated by computer simulation. The simulation results indicate that under the most favorable circumstances, the value of resupply orders directed by the VOSL stocking model exceeded

DD FORM 1473 1 JAN 73 (Page 1)   EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-014-6601

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

(20. ABSTRACT continued)

the grants made by the funding policy. Under less favorable, more realistic conditions, the difference between funding requirements and funding grants is more marked and supply performance degrades very significantly over time. The funding dilemma investigated in this study is well known to Navy stock points and they have devised various ways of attempting to deal with it. Significantly, even in a climate of insufficient funding, system stock policies (VOSL) provide better performance than locally devised policies.